IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
Before the Board of Patent Appeals and Interferences

In re Patent Application of

ROHR et al

Serial No. 09/955,297

Filed: September 19, 2001

Title: PHOTOVOLTAIC DEVICE

Atty Dkt. 550-269

         C#   M#

TC/A.U.: 1753

Examiner: Brian Mutschler

Date: November 22, 2004

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

☐ **Correspondence Address Indication Form Attached.**

☐ **NOTICE OF APPEAL**
   Applicant hereby **appeals** to the Board of Patent Appeals and Interferences
   from the last decision of the Examiner twice/finally rejecting   ($340.00) $
   applicant's claim(s).

☐ An appeal **BRIEF** is attached in the pending appeal of the
   above-identified application ($ 0.00   ) $

☐ Credit for fees paid in prior appeal without decision on merits   -$ (   )

☒ A reply brief is attached in triplicate under Rule 41.41   **(no fee)**

☐ Petition is hereby made to extend the current due date so as to cover the filing date of this
   paper and attachment(s) **($110.00/1 month**; $430.00/2 months; **$980.00/3 months**; $1530.00/4 months) $

                                              SUBTOTAL $ 0.00

☐ Applicant claims "Small entity" status, enter ½ of subtotal and subtract   -$(   )
   ☐ "Small entity" statement attached.

                                              SUBTOTAL $ 0.00

    Less   month extension previously paid on   -$(0.00)

                                     TOTAL FEE ENCLOSED $ 0.00

Any future submission requiring an extension of time is hereby stated to include a petition for such time extension. The Commissioner is hereby authorized to charge any <u>deficiency</u>, or credit any overpayment, in the fee(s) filed, or asserted to be filed, or which should have been filed herewith (or with any paper hereafter filed in this application by this firm) to our **Account No. 14-1140.** A <u>duplicate</u> copy of this sheet is attached.

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NIXON & VANDERHYE P.C.
By Atty: Stanley C. Spooner, Reg. No. 27,393

Signature: _____

In re Patent Application of

ROHR et al   Atty. Ref.: 550-269

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REPLY BRIEF

This Reply Brief is responsive to the Examiner's Answer mailed September 21,

2004 (Office paper does not have a Paper No. located on it), the date of response to

which is November 22, 2004 (November 21, 2004 falling on a Sunday).

The Examiner's Answer, in view of the multiplicity of errors noted in Appellants'

Appeal Brief, fails to exhibit a sufficient understanding of elementary physics. One of

ordinary skill in the art of the presently claimed invention, as set forth in the Declaration

of Dr. Neal Anderson already of record in this application (in paragraph 4) would have at

least "(a) an undergraduate degree in electrical or electronics engineering, (b) at least a

masters degree in a related electrical engineering field and (b) at least 5 years experience

in the photovoltaic cell field."

Given the above understanding and experience of one having ordinary skill in the art, Appellants will address only a portion of the multiplicity of errors replete in the Examiner's Answer in this Reply Brief. Among the errors addressed are: (1) strain is not the same as stress; (2) Appellants' independent claim requires "substantially no shear force" and not substantially no shear strain; (3) a zero strain configuration as taught in Ekins-Daukes I is not the same as a substantially zero stress combination; and (4) the Examiner has clearly ignored paragraph 12 of Dr. Anderson's Declaration.

(1) Strain is not the same as stress

The Examiner's discussion throughout the lengthy 39-page Examiner's Answer consistently comes to the conclusion that, because Ekin-Daukes I suggests that the strain in a period be minimized, stress in that period must also be minimized. This is simply incorrect, as will be understood by those of even ordinary skill in the field of elementary physics.

It is well known that for small stresses and strains, some form of Hooke's law applies, namely, that for an individual solid material, stress is proportional to strain or:

Stress = k x strain where *k* is a constant.

Those of ordinary skill in the art will realize that, in practice, the above is true for most material solids. However, such person's will understand that *k,* while a constant for one material, may be different constant in another material. The fact that different materials (all having different Hooke's law constants, *k*) are used in the claimed photovoltaic cells is significant to the understanding of Appellants' invention. It can be readily understood

that if two materials have different constants k, i.e., k_1 and k_2, and if those materials are strained, i.e., "to cause a change of form or size in (a body) by application of external force" (*Webster's Ninth New Collegiate Dictionary* at page 1164), the <u>same amount</u>, due to a difference in Hooke's law constant, the resultant stress (the force needed to cause the strain) will be different.

Thus, the Examiner erroneously concludes at multiple points in the Examiner Answer (for example, page 34, lines 13 and 14 and elsewhere) "a negligible quantity of strain provides a negligible shear force." While this conclusion might be correct for a single material with homogeneous properties (having a single constant), it is incorrect for non-homogeneous materials and certainly incorrect for different materials having different constants.

Thus, throughout the Examiner's Answer, the Examiner's predicate, i.e., that <u>negligible strain</u> provides <u>negligible stress</u>, is simply incorrect given the different materials used. The error of this conclusion would be well known to those having ordinary skill in the field to which the present application is addressed as being violative of Hooke's law. Given that the Examiner has made a clear error in the application of elementary physics, the rejection, based upon that error, cannot withstand any legitimate scrutiny.

(2) Appellants' independent claim requires "substantially no shear force" and not substantially no shear strain

Each of Appellants' independent claims 1, 18, 33 and 44 all specify the same or similar language, i.e., "each period of one tensile strained layer and one compressively

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strained layer exerts <u>substantially no shear force</u> on a neighbouring structure." (emphasis added). Appellants have previously and repeatedly pointed out that the benefit of this operational interrelationship between the tensile strained layer and the compressively strained layer in each period of a photovoltaic device provides an increase in the number of quantum wells and thus an increase in collection efficiency.

Because of the Examiner's misunderstanding of the difference between stress and strain, especially with respect to different materials, the Examiner apparently assumes that the claim limitations are shown in Ekins-Daukes I which contains a teaching to minimize the average <u>strain</u> and not the average <u>stress</u> over one or more periods.

Appellants' claimed photovoltaic device comprises a plurality of quantum wells and a plurality of barriers. The quantum wells and the barriers are different materials and obviously would have different Hooke's law constants. Appellants' claim requires that the compositions, thicknesses, etc. of "a period of one tensile strained layer and one compressively strained layer" have the interrelationship that they exert "substantially no shear force on a neighbouring structure."

It is known that different k values will occur in deep quantum wells and high barriers, as are required in photovoltaic device. The present invention becomes more significant for high well numbers as required by a more efficient photovoltaic device. Appellants' realization that the most efficient system can be achieved by reducing, ideally to zero, the net force in any single period of the multilayer structure, i.e., zero net stress. This inventive realization is set out in each of Appellants' independent claims.

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The Examiner in his Answer has not indicated how or where any prior art reference teaches minimizing the stress for any single period or, for a multi-period structure, minimum net stress. The Examiner errs in his conclusions that (a) stress is the equivalent of or equal to strain, and (b) that the Ekins-Daukes I suggestion of minimizing strain is a disclosure of minimizing stress. The Examiner has provided no support for his conclusion, and this conclusion is contrary to even elementary physics as would be well known by those of ordinary skill in the art. Accordingly, the Examiner's erroneous conclusion does not support the rejections based upon the Ekins-Daukes I reference.

(3) A zero strain configuration as taught in Ekins-Daukes I is not the same as a substantially zero stress combination

In the last paragraph of page 34 and the first several paragraphs of 35 of the Examiner's Answer, the Examiner suggests that the "example" discussed in Appellants' Appeal Brief is not shown in the Ekins-Daukes I reference ("Ekins-Daukes et al. do not provide any such 'example.' Nowhere in the Ekins-Daukes et al. reference does such an example appear"). The Examiner apparently misunderstands Appellants' Appeal Brief in the paragraph bridging pages 13 and 14. Appellants were not saying that the example of +4 strain and -4 strain is taught in the Ekins-Daukes I reference – what is taught in Ekins-Daukes I is that one wishes to have the average strain be zero or at least minimized.

Appellants created an example whereby one should be able to understand that, if the strain between one period and its adjacent period was +4 and then the strain between that period and a further period was -4, the average strain over those two periods is zero (+4 and -4 cancel each other out). Thus, there would be no strain.

This zero strain concept is precisely what the Examiner refers to as being taught in Ekins-Daukes I. However, the Examiner apparently does not appreciate that different materials have different Hooke's law constants k, and that the strain and stress relationship is not such that "a negligible quantity of strain provides a negligible shear force" as contended by the Examiner throughout the Examiner's Answer.

Appellants have prepared an Exhibit (which is also not shown in the Ekins-Daukes I reference) which illustrates strain and stress relationships and demonstrates that it is possible to have zero strain and yet substantial stress in the Ekins-Daukes I organization of elements. It clearly demonstrates how Appellants' invention can provide "substantially no shear force on a neighbouring structure" as required by the claims.

The Ekins-Daukes I arrangement is shown in Figures (a) and (b) on the attached Exhibit. In Figure (a), it is assumed that k_1 for the layer of white atoms is greater than k_2 for the layer of black atoms. The strain is the amount the layer by itself has to be compressed or tensed (depending upon whether it is squeezed or stretched) to meet the dimension of the resultant crystal lattice (the resultant dimension of the layer is shown with the gray layer of atoms).

Ekins-Daukes I teaches, as the Examiner contends, that the strain should be minimized, i.e., the strain in each of the layers should be minimized so that there is a negligible average strain. Quite clearly, if the strain on the layer of black atoms is x_1 and the strain on the layer of white atoms is x_2 (i.e., the strain is equal), when those layers are combined to form a crystal lattice structure as shown in (b), the strain in each layer will be minimized.

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Clearly if the same materials were used in the black and white layers, the constants k_1 would be the same and the combination of layers would be not only strain balanced, but also stress balanced. However, this is not the case as the layers are of different materials which have different coefficients k_1 and k_2. Because k_1 is greater than k_2, even though as shown in Figure (b) there is minimal <u>strain</u>, there is a <u>stress</u> imbalance as shown by the different length force vectors shown at the crystal interfaces between the white and black layers. While there may be zero net strain (because x_1 equals x_2), there is not a zero net stress, and the inward force exerted by any layer of white atoms is counterbalanced by the outward force exerted by the adjacent layer of black atoms, as indicated by the arrows.

The difference between the constants, i.e., k_1 greater than k_2, means that the stress in the white layer is larger than the stress in the black layers. Because of this difference in stress, there is a net shear force on each neighboring period, and the consequence is that many fewer quantum wells can be grown before the material relaxes. As a result, the Ekins-Daukes I type device is significantly less efficient, even though it may be <u>strain</u> balanced, than a device which is <u>stress</u> balanced as set out in Appellants' claims, which can have many more wells and thus provide a higher degree of photovoltaic conversion efficiency.

The claimed invention is shown in Figures (c) and (d). The same layers of black and white atoms are used, with the same relationships of k_1 and k_2. However, the composition and thickness and other aspects of each layer are adjusted in accordance with Appellants' claims so as to provide minimal stress in the resulting crystal lattice. As

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shown, the thickness of the white atom layer and the thickness of the black atom layer are chosen to be different such that, when they are compressively and tensilely strained into the crystal lattice structure, the amount of compressive force exerted by the white crystals is substantially identical to the amount of tensile force exerted by the layer of black atoms. As a result, the combination of elements has "substantially no shear force on a neighbouring structure." This can be diagrammatically seen as the identical force vectors at the interface between each layer of black and white atoms.

Thus, Appellants' claimed invention is the realization that strain balance is only one portion of the equation and Appellants' consideration of stress balancing provides the benefit of higher efficiency photovoltaic devices.

It is submitted that the above clearly shows that the Examiner's conclusion that "a negligible quantity of strain provides a negligible shear force" is patently incorrect. The prior art made in accordance with Ekins-Daukes I shows in Figure (b) that there is no strain difference – both layers are strained or deformed the same amount x_1 equals x_2. Therefore, there is a negligible quantity of strain.

However, there clearly is a substantial difference in stress between the layers, and the stress on the layer of black atoms is certainly not equal to the stress on the layer of white atoms. Thus, Figure (b) clearly discloses a situation in which there is a negligible quantity of strain, but with a substantial shear force, directly contrary to the Examiner's understanding.

Because of the Examiner's misunderstanding and misapplication of the Ekins-Daukes I reference and because this misunderstanding is the predicate for the entire

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rejection of Appellants' claims, there is simply no support in elementary physics for the Examiner's conclusions.

(4) The Examiner has clearly ignored paragraph 12 of Dr. Anderson's Declaration

The Examiner's misunderstanding of the teaching in the Ekins-Daukes I reference and his conclusions have been considered and documented in a Rule 132 Declaration by Dr. Neal G. Anderson. Dr. Anderson is unrelated to the Appellants or the Assignee of the current invention.

Dr. Anderson is a well-known professor at the University of Massachusetts at Amherst, has been a PhD for approximately 16 years, has written numerous publications, presentations and reports dealing with quantum well, solar cell and photovoltaic cell deficiencies, has taught numerous undergraduate and graduate courses and has actually been awarded the Outstanding Teacher Award in 1993 at the College of Engineering at the University of Massachusetts.

Dr. Anderson not only set out in paragraph 4 that based upon his teaching of undergraduate and graduate students, the level of skill of persons having ordinary skill in the art in the photovoltaic cell field, he also states in paragraph 5 that he has reviewed the Final Rejection mailed by the patent examiner on January 27, 2003. Dr. Anderson testifies that he concludes in paragraph 11, that "the Examiner errs in his conclusion that the requirement of claim 1 that 'a period of one tensile strained layer and one compressively strained layer exerts substantially no shear force on a neighbouring structure" is ensured by the Ekins-Daukes I disclosure of a thickness-weighted average

lattice constant approach as in equation 1 of Ekins-Daukes I." In other words, there is clear evidence that the Examiner's conclusion is incorrect. Dr. Anderson goes on to point out that "the Ekins-Daukes I disclosure teaches that the thickness-weighted average lattice constant of wells and barriers is roughly the same as the InP substrate **but this is insufficiently exact to ensure periods which exert 'substantially no shear force on a neighboring structure'.**"

The above evidence was made of record in Appellants' Rule 116 Amendment filed July 22, 2003, and these arguments were presented to the Examiner at that time. The Examiner did not enter the Amendment and Appellants requested continued examination which was granted in the Official Action mailed August 27, 2003, wherein, subsequent thereto, a Final Rejection was mailed and led to the present appeal. Therefore, the Declaration of Dr. Anderson has been of record in this case for a year and a half and has clearly never been controverted by the Examiner with any evidence supporting any contrary conclusion. The Examiner has consistently denied the facts set out by Dr. Anderson's Declaration, but has failed to provide any evidence supporting the Examiner's view.

The only evidence of record in this appeal, other than the prior art references, is Dr. Anderson's opinion testimony as an expert in the field of photovoltaic devices. This evidence has not been controverted and therefore must be considered by the Examiner. Great weight should be given to this evidence, since Dr. Anderson is not an employee of the assignee, nor is he a member of or associated with the Imperial College of Science, Technology and Medicine in London, England, the assignee of the current application.

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Based upon Dr. Anderson's Declaration alone, it is clear that the Examiner has failed to meet the requirement of establishing a *prima facie* case of obviousness based upon the Ekins-Daukes I reference or any other cited reference.
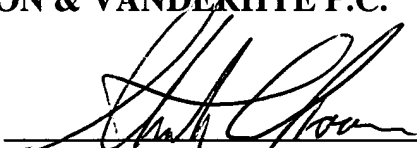
Accordingly, for the reasons set out in Appellants' Appeal Brief, the Examiner has simply failed to meet his burden or establishing a *prima facie* case of obviousness. The above Reply Brief responds to the majority of errors in the Examiner's Answer and attempts to correct the Examiner's misunderstanding of elementary physics and in particular the physics of crystalline structure resultant from layers of different materials being deposited thereon.

In view of the above, the rejection of claims 1-18, 20-27, 31-33 and 35-58 over the cited prior art is clearly in error and reversal thereof by this Honorable Board is respectfully requested.

Respectfully submitted,

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Enclosure:
  Exhibit 1

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x_2—|—
|—x_1

k_1

k_2

k_1

a_1

a_2

a_1

a_0

$x_1 < x_2$
$k_1 > k_2$
(c)

x_2—|—
|—x_1

$x_1 < x_2$
No force
(d)

x_1—|—
|—x_2

k_1

k_2

k_1

a_1

a_2

a_1

a_0

$x_1 = x_2$
$k_1 > k_2$
(a)

x_1—|—
|—x_2

$x_1 = x_2$
Net force
(b)